BE IT KNOWN that **WE**, Bernhard LUCAS, Frank SCHATZ, Juergen SEIZ, Heinz EISENSCHMID, Andreas KUGLER and Achim DIETERICH, citizens of Germany, whose post office addresses and residencies are, respectively, Zehenderstrasse 2, 74354 Besigheim, Germany; Tellstrasse 29, 70806 Kornwestheim, Germany; Baumbluete 11, 73642 Welzheim, Germany; Ludwigshafener Strasse 7, 70499 Stuttgart, Germany; Teckstrasse 13, 73553 Alfdorf, Germany; and Spielhof 25, 71540 Murrhardt, Germany; have invented a certain new and useful

CIRCUIT DEVICE WITH A CONTACT ELEMENT FOR ELECTRICALLY CONNECTING A WAVE GUIDE AND A CONDUCTOR STRIP IN A NEARLY STRESS-FREE MANNER

of which the following is a complete specification thereof:

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a circuit device with a contact element for electrically connecting a wave guide to a conductor strip.

2. Prior Art

A so-called stepping transformer, whose geometry is substantially determined by the wavelength of the frequencies used, is employed in high frequency circuitry in a frequency range over 50 GHz at the junction between a wave guide and conductor strip circuit elements.

Usually an electrical connection of the final stage of the stepping transformer to the conductor strip circuit device is required. This electrical connection is, for example, accomplished by glued conducting small gold bands. These small gold bands are either mounted over a corner or on the bottom side of the final stage. This fabrication method is very expensive. Furthermore the electrical connection is put under great mechanical stress by possible relative motion due to differing thermal expansion of the metallic wave guide and the dielectric conductor strip substrates.

Summary of the Invention

It is an object of the present invention to provide a circuit device with a contact element for electrically connecting the wave guide to a conductor strip, which does not have the above-mentioned disadvantage.

According to the invention the contact element electrically connects the wave guide with the conductor strip by means of two contacting areas and is made from an accurately prefabricated coil spring having predetermined reproducible properties. This coil spring is connected at one of the contacting areas to the conductor strip or to the wave guide by means of an electrically conductive glue and another of the contacting areas is a sliding contact whereby the coil spring is pre-tensioned; or is provided by an electrically conductive glue or adhesive portion, whereby the coil spring is bent into a U-shape; or is provided with a highly flexible electrically conductive adhesive section.

This type of electrical connection is easy to make. Different thermal expansion properties of the different materials are easily and satisfactorily compensated.

Advantageous additional embodiments are set forth in the dependent claims. Their features, in so far as it is appropriate and significant, may of course be combined with each other.

The sliding contact can move with the participating structural elements without experiencing significant mechanical stresses due to relative motions

(originating , for example, from differing thermal expansion properties). Without the device according to the invention the contacting areas would be subjected to impermissibly large mechanical stresses. The motion is compensated by the coil spring itself and/or by the pre-tensioned sliding contact in a nearly stress-free manner.

Relative motion of the parts occurs without tearing off the contact element. The contact junction is reproducible and not dependent on the bonding form and processes. Thus the electrical tuning between the wave guide and the conductor strip is reproducible.

The coil spring for applications in the highest frequency engineering is especially small (length, about 100 to 200 μm, thickness about 50 μm). The coil spring is formed with very great accuracy, particularly as a so-called MIGA coil spring(MIGA = microgalvanic). UV depth lithography or comparable methods of structuring polymers in combination with multilayer microgalvanic methods are suitable for making the coil spring. Laser processing or high precision punching or stamping can be suitable for making the coil spring.

Thus simple but precise or exact fabrication methods are possible for the coil spring. Tolerances of $< \pm 10$ μm may be obtained for the above-described contact element with UV depth lithography. A wide range of materials can be selected so that special spring properties can be obtained. An automatic mounting of the coil spring and easy manufacture of the electrical connection are possible. Several coil springs can be economically made at the same time in a batch process (which means for many applications).

Brief Description of the Drawing

The objects, features and advantages of the invention will now be illustrated in more detail with the aid of the following description of the preferred embodiments, with reference to the accompanying figures in which:

Figure 1 is a schematic cutaway cross-sectional view through a first embodiment of a circuit device with a contact element for connecting a wave guide to a conductor strip;

Figure 2 is a schematic cutaway cross-sectional view through a second embodiment of a circuit device with a contact element for connecting a wave guide to a conductor strip;

Figure 3 is a schematic cutaway cross-sectional view through a third embodiment of a circuit device with a contact element for connecting a wave guide to a conductor strip;

Figure 4 is a schematic cutaway cross-sectional view through a fourth embodiment of a circuit device with a contact element for connecting a wave guide to a conductor strip; and

Figure 5 is a schematic cutaway cross-sectional view through a fifth embodiment of a circuit device with a contact element for connecting a wave guide to a conductor strip.

Description of the Preferred Embodiments

A wave guide 1 in the form of a stepping transformer and a conductor strip substrate 2 rest on a metal plate 5. The wave guide is screwed on the metal plate 5. The form of the stepping transformer is not described here in detail. The conductor strip substrate 2 is glued on with the help of an electrically conductive adhesive material or glue 6. The conductor strip substrate 2 is provided on its upper side with a conductor strip 7. This conductor strip is a component of a microwave IC (MIC). The wave guide 1 has a coupling opening 8 in the vicinity of the conductor strip.

According to figure 1, a coil spring 11 operating as an electrically conductive contact element is bonded to the conductor strip 7 at a first contacting area 9 with an electrically conducting glue or adhesive . Silver-filled epoxy resin glue is suitable as the adhesive material. The wave guide 1 is assembled after the coil spring 11 has been bonded with the adhesive, so that the mechanically pre-tensioned coil spring 11, which forms a sliding contact 10 at a second contacting area 9', presses resiliently against a surface 1a of the wave guide 1, which extends substantially perpendicularly to the plane of the conductor strip 7. The contact element forms a low impedance contact between the wave guide 1 and the conductor strip 7. This low impedance connection is required in order to permit an optimum tuning of the coupling of the electromagnetic waves from the

wave guide 1 into the conductor strip 7. Besides the geometry of the junction plays an important role

Relative motions, especially thermally dependent relative motions, between the wave guide 1 and the conductor strip 7 are compensated with the help of the sliding contact 10 and the spring force of the coil spring 11. Without this device the contacting areas would be subjected to impermissibly large mechanical stresses.

Figure 2 illustrates another embodiment for the coil spring 12. This embodiment is similar to the embodiment shown in Fig. 1, but differs from it because the surface 1b of the wave guide 1 on which the coil spring 12 bears is substantially parallel to the conductor strip 7.

This latter situation in regard to Fig. 2 is also true of the third embodiment shown in Fig. 3. In the embodiment shown in Fig. 3 a sliding contact 10 of a coil spring 13 is located in a cavity 1c of the wave guide 1. It is also possible to additionally secure the spring contact in the cavity with a highly flexible electrically conductive glue or adhesive material.

In the embodiment shown in Fig. 4 a coil spring 14 is electrically conductively glued to the wave guide 1, while the sliding contact 10 makes electrical contact on the conductor strip 7 on the other conducting area 9'.

In Figure 5 in a fifth embodiment the coil spring 15 has a curved U-shape. The coil spring 15 is glued in an electrically conductive manner to a first contacting area 9 on the conductor strip 7. The other contacting area 9' of the coil spring 15 is formed as an electrically conducting adhesive area 16. This adhesive

area 16 can however by highly flexible. The coil spring 15 needed not then be formed so that it is U-shaped.

The disclosure in German Patent Application 199 02 240.2 of January 21, 1999 is incorporated here by reference. This German Patent Application describes the invention described hereinabove and claimed in the claims appended hereinbelow and provides the basis for a claim of priority for the instant invention under 35 U.S.C. 119.

While the invention has been illustrated and described as embodied in a circuit device with a contact element for electrically connecting a wave guide and a conductor strip in a nearly stress-free manner, it is not intended to be limited to the details shown, since various modifications and changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention.

What is claimed is new and is set forth in the following appended claims.